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FUNDAMENTAL PROBLEMS OF CONTEMPORARY ENGINEERING

T. L. Zolotarev

Mechanization

The mechanization of labor-consuming processes is the most important problem of the new Five-Year Plan. Mechanization of technological processes requires special machines, such as, channeling machines for the coal industry; concrete mixers, etc., for the construction industry; rollers, graders, etc., for highway construction, and all kinds of farm machines for the agricultural industry.

Complete mechanization of all productive processes is being widely developed in the Soviet Union. It is possible to unite a number of processes in one machine. Such "combines" are appearing in all branches of industry. In agriculture, along with self-propelled (without tractors) grain combines, potato harvesters, cotton harvesters, and other combines are under construction.

In 1945, cutting coal in the USSR was 94 percent mechanized; conveying coal from the cut to the drift was 84 percent mechanized; haulage was 74 percent mechanized, while loading on the conveyer was only 2 percent mechanized. New Soviet-constructed coal combines have been developed which cut, break, and load coal on conveyers.

Complete mechanization of labor-consuming processes is being effected in the reconstructed ferrous metallurgy factories of the south. Labor-consuming processes in removing small defects (cracks, overheated spots, cinders) are being replaced by pyro-refining with oxyacetylene flame of hydraulic refining with water jets. This method of hydromechanization, using water jets under high pressure, also can be used in mining deposits and transportation. It is used in the construction of earth dams, in excavations, and fills, and in mining coal, ore, and turf.

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At the end of the Five-Year Plan in agriculture, mechanization must be raised from 55 percent (grain harvesting) to 90 percent plowing, steam lifting, and refrigeration); in construction work, from 50 percent (painting) to 95 percent (concrete production); and in loading and unloading work in transportation to 75 percent.

In the USSR in 1940, electricity was already used as the power source for five sixths of the pool of working machines.

In 1950, the power supply of the USSR will be raised to 82 billion kilowatt hours, 70 percent greater than the prewar supply.

Electrification increases the productivity of labor and changes working conditions in agriculture. It makes possible electric pumping, electric threshing, electric drying of grains, electric heating of hothouses, and X-ray exposure of fruits which increases size and improves quality and taste. According to the Five-Year Plan, many thousands of kolkhozes will be electrified. This requires construction of 18,000 small hydroelectric power plants with a total power of a million kilowatts. Labor productivity will be increased many times, and millions of men will be released from agricultural tasks.

One of the laws of high productivity is continuity of the process. Therefore, new engineering is characterized by the replacement of interrupted periodic processes by continuous ones.

Reciprocating steam engines are being replaced by steam turbines; piston compressors by turbocompressors; percussive boring machines by rotating drilling machines, and flat printers by rotary presses.

Process continuity has special significance in the chemical industry with which it is organically linked. Process continuity in oil production, and in the production of synthetic rubber and plastics, has already been achieved.

Mass-production methods are used in all branches of industry. Even in a field such as the construction of hydroelectric power plants, where each river requires a separate approach, mass-production methods are being designed. At the Molotov Hydroelectric Station, under construction on the Kama River, the mass produced units will be blocks mounted in the body of the dam. Similar low-pressure stations may be assembled from standard blocks. This will cheapen and accelerate construction.

All this work requires machines. Therefore machine construction is the foundation for raising the technical level in the development of the economy. Stalin has called machine construction the heart of heavy industry. There are no machines that our factories cannot build. In 1950, the number of machines in the USSR will be 30 percent greater than the number in the US in 1940. Their number will increase to 1,300,000. The number of types will approach 1,000.

The basic problem of contemporary engineering is that of increasing efficiency. For power transformation, this is expressed by the efficiency or the ratio of the useful energy to that expended; for transformation of materials, this index is the coefficient of utilization of the material.

The present-day thermoelectric power plant transforms only about one quarter of the thermal energy into electric power; that is, its efficiency is 25 percent. Each percent increase in the efficiency of thermoelectric power plants in 1950 would bring us an additional 700 million kilowatt hours of electric power and save 350,000 tons of coal! These figures indicate the importance of perfecting all processes of transforming fuel energy (coal, liquid fuel, wood, peat) into electric power.

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The sugar beet is another example. Three of the 17 percent of sugar contained in the sugar beet, by present-day refining methods, is left in the press, waste products, and syrup. If we could reduce these losses from 3 to one half of one percent, we could obtain an additional 30 million pud of sugar in 1950 without increasing the quanitiy of sugar beets refined.

Increased Utilization of Waste Products

1. Increasing the Quality of Raw Materials

Ore, coal, and other raw materials are now being successfully enriched in our industries; solid fuels are often transformed into a powdered form for this purpose. Even more efficient is the gasification of fuel, since gas is easily transported in pipes. Moreover, gas is the basic raw material for industrial chemistry. Gasification is one of the methods of power-chemical combination and permits the successful utilization of second-grade fuels. Another highly promising new engineering attainment is the derivation of liquid fuel from cheap lignite. Up to 180 kilograms of liquid fuel can be obtained from a ton of lignite.

2. Combination

The use of secondary power resources is becoming widespread in industry. An example of secondary power utilization is a steam turbine driven by hot steam. However, the turbine does not use all the energy of the steam. The steam, having done a little work in the turbine, still retains part of its energy in the form of heat. Therefore the exhausted, but still hot, steam is utilized in heating and superheating water and air. In the new Stalin Five-Year Plan, 21 new thermoelectric centrals will be put into operation. Combined production of power will increase the efficiency of units and save hundreds of thousands of tons of fuel.

It is impossible to increase the economy of heating units by another method. Instead of one working medium (usually water), two are utilized. Thus, mercury is heated, and the mercury vapors work in a mercury turbine. The exhausted mercury vapors heat water with their remaining heat, transforming it into steam. The steam, in its turn, works in a steamheating turbine. Such dual (binary) mercury-water units have already been used. Their efficiency is higher than that of the usual units by 10-15 percent. They save thousands of tons of fuel.

In the first years of its operation, the Dnepr hydroelectric power plant could not use all the flood water available in spring, and in winter there was no water for the production of electric power. But, when the hydroelectric power plant was connected with the Donets Basin thermoelectric power plant power plant by electrical transmission lines, harmonious working conditions for both were established. The spring surplus of power from the hydroelectric power plant is transmitted to the Donets Basin. At this time, the thermoelectric power plant repairs its machines and saves fuel. In winter, the thermoelectric power plant aids the Dneprovskaya hydroelectric power plant, and their power is transmitted to the area around the Dnepr.

The connection of electric power plants into one system and their interconnection increases the utilization of each. The interconnection increases security of supply to the consumer, since power may be transmitted from different stations.

At present, the transmission of electric power over great distances is effected along three conductors by high-voltage, three-phase, alternating current. Power transmission using alternating current presents serious engineering problems. An increase of transmitted power, or range of transmission, makes voltage regulation and stability of transmission more difficult and expensive. According to calculations, the maximum transmission distance for alternating current is 1,500 kilometers, but even at distances above 500 kilometers, transmission becomes complex and difficult. Utilization of high-power hydroelectric power plants requires an increase in the range of transmission. During the planning of the Kuybyshev hydroelectric power plant, a problem arose concerning the transmission of 1,200,000 kilowatts to Moscow, 900 kilometers away. Longer transmission distances will be required for utilizing the power of the huge hydroelectric power plants which will be constructed on the Yenisei, Angar, and other rivers, and also in utilizing the power of the high-tide-low-tide units in the White Sea and along the northern shore of the Arctic Ocean.

Thirty years ago, the outstanding Russian engineer, M. O. Dolivo-Dobrovol'skiy, saw the necessity for changing to power transmission by high-voltage direct current. Direct current, using voltages of a million volts or higher, may be transmitted over distances up to 4,000 kilometers. Moreover, direct current transmission requires only two conductors. Direct current may be transmitted by underground cables which will withstand voltages several times higher than for alternating current. But the whole difficulty lies in creating machines which will transform the high-voltage alternating current, produced by the stations' generators, into super-high-voltage direct current (rectifier) and back (invertor). Scientists and engineers are working intensively on this problem now. A special Direct-Current Research Institute has been established.

Refining of materials presents great possibilities for the utilization of waste products. For example, we have learned to obtain ethyl alcohol from the sawdust of the lumber industry. Formerly, sawdust was hardly ever utilized. Hydrolysis, a new branch of industry, has been developed. Power-chemical combination has the greatest potentialities in the field of waste products utilization. By this method, the power source serves simultaneously as power and a raw material for chemical production. The chemical industry obtains more than a million valuable organic compounds from oil, besides its use as a fuel. Coal, peat, and shale are now converted into a universal raw material. Coal obtained in the Moscow basin is of inferior quality. It yields only one half as much heat as Donets coal and contains up to 30 percent ash. The Stalinogorsk Chemical Combine, established before the war, uses this coal as a raw material. Low-grade coal is burned under the fireboxes of the boilers in the electric power plant (the electrical power is transmitted 220 kilometers to Moscow). Even after this a great deal of ash remained. An ash dune grew around the station. Now, engineers have learned to transform this residue. From the ash cement substitutes, cable covers, and insulators, have been developed, and soon it will be technically possible to obtain aluminum oxide, the raw material for the production of aluminum. Thus even the poorest coal is completely utilized.

In Central Asia, two power hydroelectric power plants have been constructed on the Chirchik River. Their power will be transmitted to a chemical combine. Here it will separate water into hydrogen and oxygen and draw nitrogen from the air. The raw material for the combine are unlimited (water, air). The water and nitrogen will be united into nitrogen fertilizers which will increase the harvest. In power-chemical combines, power and chemical transformations are organically and completely intertwined, yielding the highest degree of utilization. [*Industriya*, 28 August 1940, refers to the above plant as follows: "It is necessary to push the construction of equipment for obtaining heavy water on an industrial scale at the Chirchik Nitrogen Fertilizer Combine, which is now being organized."]

Directly Increasing the Coefficient of Utilization

1. New Devices

Engineers are constantly watching for new forms of transformations which will increase the utilization of power, materials, and equipment. To such new forms belongs the uniflow boiler of Razmin. There is no drum in this boiler. The boiler consists of pipes, in which the water enters below, and the high-temperature steam comes out above. The movement is in one direction -- direct flow.

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Automotive and air transportation are now using gasoline or motor fuel almost exclusively. One of the most important problems is the use of cheap local fuels in automotive and aircraft motors. The change to Diesel motors, which operate on cheaper fuel, will widen the range of fuels that can be used. The transition to motors using gas, obtained in the gasification of any fuel, is very important. Such gas-generating units have obtained wide use in automotive transportation and operate on wooden blocks and coal. In the very near future, practical gas-generators for peat and other local fuels will be designed. In the new Five-Year Plan, all high-power motor trucks will be equipped with Diesels or more economical gasoline motors. The production of gas-generating automobiles and tractors will continue to increase.

New devices for the transformation of materials are linked with the search for new methods of machining parts which reduce waste. Electric welding, replacing riveting, not only substantially increased the productivity of labor, but also saved metal up to 20 percent. Waste was sharply curtailed in the transition to stamp-welding construction. New economical dressing methods have appeared: pouring under pressure and centrifugal pouring. The general trend is an effort to reduce weight. Making the construction as light as possible saves material and labor. Extra tolerances in rolling, according to the calculations of the Glavmetallosbyt, took 600,000 tons of metal before the war. Savings in material and space may be attained by the use of new materials which are more effectively utilized. Previously, the weight of a one-horsepower motor was 3 kilograms, now it is only one kilogram.

2. Intensification of Processes

During the past Five-Year Plan, the speed of turning out sheet glass on Furko machines increased from 50 to 100 meters per hour. Automats, producing electric light bulbs, have increased their productivity ten fold and now produce up to a million lamps in 24 hours. Previously, 900 meters of sheet steel per minute came from a rolling mill, now 1,500 meters are produced. The cutting speed on contemporary machines has attained the speed of airplanes. Grinding machines, working on holes with diameters of less than a millimeter, make up to 120,000 revolutions per minute. These examples may be multiplied endlessly.

Along with speeds, pressures have also increased. Before the war, steam pressure in turbines did not exceed 40 atmospheres. In 1945, a 100,000 kilowatt steam turbine working at a pressure of 90 atmospheres was built in the USSR During the new Five-Year Plan, experimental boilers with pressures up to 300 atmospheres will be constructed and tested. Even before the war, high pressures were used in chemical production; 220 atmospheres in the production of nitrogen fertilizers; and 400 atmospheres in the production of synthetic fuel. Now pressures in thousands of atmospheres are discussed. A highly promising new branch of engineering has been established; the chemistry of high pressures. The concentration of power in separate units is also increasing. In 1932, the most powerful aircraft engine (gasoline) known was 1,200 horsepower. After the war, in the US, motors with power up to 7,000 horsepower were constructed. The power of individual water turbines has exceeded 100,000 kilowatts, and heating turbines, 200,000 kilowatts.

Temperature is also increasing. Before the war the steam temperature in boilers approached 350 degrees, and now it approaches 600 degrees. Increasing parameters either accelerate the process, increase efficiency, or save material. As a whole, they intensify the process. A 100,000-kilowatt turbine with 90 atmospheres pressure and steam temperature of 480 degrees centigrade located in the Stalinogorsk electric power plant, saves up to 15 percent of fuel in comparison to the usual turbine with a pressure of 29 atmospheres at a temperature of 400 degrees centigrade. This saves more than 100,000 tons of Moscow coal per year. Therefore, it is necessary to strive to increase the parameters still further. The basic obst le to the further increase of the parameters is the quality of materials. For the use of pressures of 100 atmospheres and temperatures of 500 degrees Centigrade, special stainless chrome-nickel steels are necessary. The quality of contemporary materials -- heat resistance, anticorrosiveness, and resistance to mechanical tensions -- determines the limit for increasing the parameters. In a number of processes, primarily in the chemical and metallurgical industries, a special method for intensification is the introduction of oxygen. Oxygen sharply accelerates combustion and certain chemical processes. In the present Five-Year Plan, powerful compressors and units for oxygen generation will be constructed. The Novotul'skaya open-hearth furnace is the only one in the world with an oxygen blast. Oxygen enters into the open-hearth process, in the production of nonferrous metals, and into the production of nitric and sulfuric acids.

3. Consolidating the Stages of Transformation

The internal combustion turbine combines the boiler and the steam turbine, i.e., it unites two stages of transformation of energy. Such compounding increases efficiency. The internal combustion turbine can operate on either liquid or gaseous fuel. It has a great future, especially in water, railway, and air transportation.

In hydroelectric power plants the so-called "circulating" unit has already been put into operation. In it, the turbine and generator have been united into one machine. The working wheel of the turbine is also the generator rotor. Such constructive compounding makes the unit lighter and improves it. Power users are striving towards the same ends. Soviet Inventor Fradkin joined the rotor of an electric motor with the working shaft of a machine. Driving gears and couplings are reduced. Similar typographical and textile machines are now in use.

Subsurface gasification is an ideal arrangement for compounding transformations of the chemical energy of coal into the chemical energy of gas directly in the coal layers. Large-scale subsurface gasification of coal was first effected in the Soviet Union. The process itself is very simple. Air, enriched with oxygen, is brought through one shaft to the coal layer, and the coal burns in carbon monoxide. The gas rises upward to the distributor through another shaft. This regulated underground combustion permits the gasification of coal without raising it to the surface, without expenditures for the construction of shafts, and without expensive underground work. Moreover, the ash remains underground. Underground gasification of coal will yield 920 million cubic meters of gas in 1950. Work is now being done on underground gasification of oil.

Direct synthesis is being widely employed in the transformation of materials. Instead of a sequence of transformations in a chain of reactions, the end product is obtained directly from the raw material. The usual oil refining (cracking) gives a 40-45 percent yield of gasoline. The present-day catalytic process of hydrogenation increases the yield of gasoline from the same oil to 80 percent. Ethylene chloride is now obtained directly from acetylene instead of by a four-stage system of transformation. Methods of obtaining nitric acid and ozone directly from the air have already been suggested. Direct synthesis is a development in the chemical industry having great promise.

4. New Prinicples of Transformation

Gas electrochemistry has opened a new field. Many materials were first obtained in an absolutely pure form by this method. Gasoline with high antiknock properties is obtained from oil products at a temperature of 500 degrees centigrade. Methane is transformed into methanoic acid. Electrothermics includes

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electric furnaces, electric heating, and electric smelting. Electric smelting eliminates chemical admixtures. Electric steel represents an increasing fraction of the world's steel production. High-frequency current is very useful in metal refining. In high-frequency furnaces, where metal is smelted, a magnetic field gives the metal a circulating motion against a hard brush and removes the slag crust from it. A new method of metal working using electrical discharges (electroerosion) was discovered in the Soviet Union. B. R. Lazarenko, Laureate of the Stalin Prize, perfected this process. Working the surfaces of metals, or drilling any type of holes in the very hardest of metals is easily accomplished by electroerosion which may replace many types of machines in the future.

The use of high pressures has opened up a new field in chemical technology. In 1946, pressures up to 450,000 atmospheres were studied. However, control over processes taking place at pressures exceeding 100,000 atmospheres has still not been worked out. High pressures open up new methods in extracting metals from ores. Lixiviation of nonferrous metals from sulfur ores under high pressure permits a more complete extraction of the metals, and separates sulfur in the form of a valuable chemical fertilizer (ammonium sulfate). High pressures permit combining the chemical and hydrometallurgical industries. High pressures make it possible to obtain a most valuable chemical raw material, acetic acid, directly from a mixture of carbon monoxide and hydrogen.

5. Automatization

Automatization permits regulation of the speed of chemical reactions. Now useful reactions are regulated with a precision of .01 second. An electronic instrument has been built which will measure the flight speed of a projectile with an accuracy of 0.00001 second. The production of the modern tank is controlled by 7,000 measuring instruments, which, in their turn, require 3,000 calibrating instruments for checking. In the present Five-Year Plan, our production of control and measuring instruments must increase sevenfold. Only automatization will permit the intensification of processes. Without it, it would have been impossible to accomplish the interconnection of electric power plants. In case of any ground in the circuit, the automatic instruments register the breakdown, and automatically cut out the damaged sections.

From the automatic machine, it is possible to transfer to automatic lines of machines. Eighty universal machines and 58 workers were required to make cylinder heads for the motor of the KhTZ tractor by the usual method. The automatic line, set up in the "Stankokonstruktsiya" Factory in Moscow in 1946, consists of 14 machines serviced by only two workers. The line reduced the time needed to make the parts by eight times. The automatic line of machines for motor blocks of the ZIS-150 automobile consists of 16 machines placed in two rows. Drilling, boring, counterboring, and control are carried out simultaneously on 536 different forms of cutting and measuring instruments. The line is serviced by two workers and produces 30 blocks per hour. The next step in the development of automatic lines is the union of mechanical processing (cutting, pressure) with thermal (high-frequency current-tempering, cementation, drying) and the chemical (degreasing, washing, dyeing) processes.

One of the hydroelectric power plants below Moscow serves as an example of complete automatization. Two machines were installed in this station. The power plant is always locked. The machines are started and stopped by a push-button in the central control point 65 kilometers from the station. A mechanic checks the station once a week, or is automatically summoned at his home if the machine suffers a breakdown.

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Remote control, which surmounts the problem of space, is closely linked with automatization, which speeds up processes. Remote control concentrates the work of many enterprises and units in one place. For example, the central control point in Yakhroma controls the operation of seven hydroelectric power plants, 11 sluices, and 5 pumping stations, located along the 128 kilometer route of the Moscow-Volga Canal. Out of 24,597 operations carried out here by automatic apparatus for one year, only 37, or 0.15 percent, were incorrect, delaying starting or stopping time, and not one caused a breakdown.

Automatization is given a great deal of attention in the new Five-Year Plan. At present, control and adjustment of metallurgical units, enriching plants and metallurgical factories, plants of the chemical industry, the production of automobile tires, the cellulose-paper industry, and the foodstuffs industry are undergoing automatization.

Radar is also attracting a great deal of interest now. The present-day radar station has an operational radius of more than 200 kilometers. In the future, radar may be used to discover useful minerals. Studies of the possibilities of concentrating microwaves into very narrow beams of enormous power will present new methods for accomplishing the wireless transmission of electric power.

New Resources

Thousands of important chemical products are obtained today by synthesis. Synthetic chemistry makes it possible to create materials with certain characteristics. An oil was needed for electrical machines and units which would have high insulating properties, would not deteriorate, and would not burn. Such an oil, pyranol, was obtained by synthesis. Polythene, the new electric insulating material which improved the radar apparatus, was also obtained by synthesis.

The most promising nonfuel power resources are river and wind power. Hydropower engineering will attain new importance in the new Five-Year Plan. Of the 82 billion kilowatt hours of electric power scheduled for 1950, hydroelectric power plants will produce 15.2 percent.

Several new power resources require further research, for example, the utilization of cold energy. For half the year in the Arctic, the air temperature is -30 degrees centigrade, while the temperature of water in rivers beneath the ice is 4 degrees centigrade. If a material could be found which would evaporate at 4 degrees centigrade, and condense at -30 degrees centigrade, it could be used as an instrument in Arctic power plants to transform this temperature drop of 34 degrees centigrade into electric power. Something has already been done in this direction, but much more remains to be done. Another possible new source is solar energy. In Uzbekistan before the war there were 20 helioboilers with a total surface of 3,000 square meters. According to the calculations of Prof Trofimov, each square meter of such a helioboiler in Uzbekistan yielded as much heat as 250 kilograms of coal during a year. Heliounits to distill water in deserts have great economic importance. Up to 18 liters of water per 24 hours may be obtained for each square meter of a helio distillation unit.

Even more attractive are methods for transforming solar energy into chemical (photochemical effect), or electrical (photoelectric effect) power. Natural photochemical processes in plants, the so-called photosynthesis, has an efficiency of 6 percent, while the present technical photochemical transformers have an efficiency of less than 0.5 percent. Photoelectric transformers are also imperfect as yet, having efficiencies in fractions of one percent. Certain "light components" may store up light and then phosphoresce after the illumination stops. According to calculations, in Moscow in the summer, solar energy yields one kilowatt of power per square meter. Considering the roof surface of Moscow as 20 million square meters, this would mean 20 million kilowatts. If some photoelectric substance could be found with an efficiency of only 3 percent, then, using it to cover the roofs of Moscow homes, we could obtain up to 600,000 kilowatts of power, which would completely take care of the power requirements of the city.

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